

FACTORS DETERMINING CRUDE OIL PRICE

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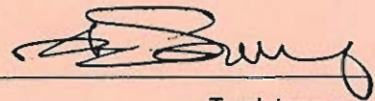
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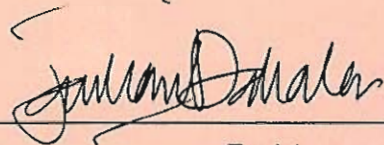
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ABSTRAK

Punca kenaikan harga minyak telah menjadi satu subjek yang diberi perhatian dan kajian mengenai kepentingan minyak sebagai sumber tenaga utama dunia. Dalam tempoh dua dekad yang lalu, harga minyak mentah telah turun-naik dengan pantas sekali dan adakalanya secara drastik. Namun, faktor yang menyebabkan kenaikan ini masih menjadi kontroversi. Kajian literatur mempunyai dua pandangan. Kumpulan pertama menghujahkan bahawa perubahan harga minyak adalah disebabkan oleh faktor asas iaitu permintaan dan penawaran. Pihak yang lain mendakwa bahawa pemboleh ubah kewangan (spekulasi dan pasaran hadapan) memainkan peranan penting dalam perubahan harga minyak. Tujuan kajian ini adalah untuk menentukan penyebab utama perubahan harga minyak mentah dengan menggunakan Model Vektor Pembetulan Ralat. Kajian ini juga untuk menentukan kesan pemboleh ubah baharu dalam pasaran minyak seperti hari penawaran hadapan dan hasil mudah terhadap perubahan harga minyak. Kajian ini memeriksa empat faktor utama yang mempengaruhi harga minyak mentah iaitu pemboleh ubah penawaran, pemboleh ubah permintaan, geopolitik dan spekulasi. Dapatan kajian menunjukkan bahawa harga minyak dalam tempoh dua dekad yang lalu terutamanya selepas krisis 2008 ditentukan oleh pemboleh ubah asas iaitu jumlah pelantar minyak, hari penawaran hadapan dan hasil mudah. Di samping itu, analisis Komponen Utama menunjukkan bahawa hari penawaran hadapan merupakan faktor terdekat sistem koordinat yang menjelaskan perubahan harga minyak mentah.

Kata kunci : harga minyak mentah, fundamental, spekulasi, model MVPR, analisis komponen utama.

ABSTRACT

Causes of oil price increase have been a subject of much interest and numerous studies given the importance of oil as the main source of energy of the world. In the last two decades, the price of crude oil has been fluctuating rapidly and at times drastically. But the causes of the rise in the price of crude oil still remained a controversy. Literature has two views. The first group argues that the changes in oil prices are due to supply and demand. The other claims that financial variables (speculation and future markets) play a big role in crude oil price changes. The objectives of this study to determine the main determinants of crude oil price changes by using the VECM model and examine the effect of the new variables in the oil market such as; days of forward supply and convenience yield on oil price changes. This study examines four main factors that affect crude oil prices which are; supply variables, demand variables, geopolitics and speculation. The results of this study indicate that oil prices in the last two decades especially after the crisis in 2008 are determined by fundamental variables which are total oil rigs, days of forward supply and convenience yield. Moreover, principal component analysis indicates that days of forward supply is the nearest factor in the PCA coordinate system which explains the changes in crude oil prices.

Keywords: crude oil prices, fundamentals, speculation, VECM, principal component analysis.

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GLOSSARY OF TERMS

Crude Oil (Including Lease Condensate)	A mixture of hydrocarbons that exists in liquid phase in underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities. Included are lease condensate and liquid hydrocarbons produced from tar sands and oil shale.
Federal Energy Administration (FEA):	A predecessor of the U.S. Energy Information Administration.
Gross Domestic Product (GDP)	The total value of goods and services produced by labor and property located in the United States.
API gravity	The American Petroleum Institute gravity, or API gravity, is a measure of how heavy or light petroleum liquid is compared to water.
Organization for Economic Cooperation and Development (OECD)	An international organization helping governments tackle the economic, social and governance challenges of a globalized economy. Its membership comprises about 30 member countries.
Organization of the Petroleum Exporting Countries (OPEC)	An intergovernmental organization whose stated objective is to "coordinate and unify the petroleum policies of member countries." It was created at the Baghdad conference on September 10–14, 1960.
Real Price	A price that has been adjusted to remove the effect of changes in the purchasing power of the dollar. Real prices, which are expressed in constant dollars, usually reflect buying power relative to a base year.
Refinery (Petroleum)	An installation that manufactures finished petroleum products from crude oil, unfinished oils, natural gas liquids, other hydrocarbons, and alcohol.
Strategic Petroleum Reserve (SPR)	Petroleum stocks maintained by the Federal Government for use during periods of major supply interruption.
West Texas Intermediate (WTI)	Also known as Texas light sweet, is a grade of crude oil used as a benchmark in oil pricing.

LIST OF ABBREVIATIONS

CPI	Consumer Price Index
CVAR	Cointegrated Vector Auto regression
C.Y	Convenience yield
DUMMY04	Dummy variable for war
EIA	Energy Information Administration
FOB	Free On Board
FRED	Federal Reserve Economic Data
GDP	Gross Domestic Product
G-20	The greatest twenty industrialized countries
ICE	International Petroleum Exchange in
IEA	International Energy Agency
L	Logarithm
LFUT4	Log for future oil contracts for four months
LOECDDAYS	Log for OECD days
LOPCAPUTIL	Log for OPEC capacity utilization
LCY	Log for convenience yield
LRIGS	Log for total oil rigs
mb/d	Million barrels daily
NYMEX	New York Mercantile Exchange
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary Least Squares
OPEC	Organization of Petroleum Exporting Countries
p/b	Per barrel
SBC	Schwarz Bayesian Criterion
S&P	Standard & Poor's
SPR	Strategic Petroleum Reserve
SRP	Sulphate Removal Package
UK	United Kingdom
UNCTAD	United Nations Conference on Trade and Development
U.S	United States
USD	United States Dollars
VAR	Vector Auto regression
WTI	West Texas Intermediate
\$/b	Dollar per barrel

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This Chapter is organized as follows: The Introduction gives a simple overview about the components of this chapter. This is followed by the Background which establishes the importance of the topic and provides a simple explanation for crude oil prices. The problem statement highlights the issues and the gaps in the literature that is going to be addressed in the study. The following subsections present the research questions, followed by the objectives of the study. Next is the significance of studying the determinants of crude oil. The scope of the study and delimitations of the study is provided in Section 1.7. Lastly, the organization of the study is laid out at the end of this chapter.

1.2 Background

Crude oil is a strategic commodity. It is a vital source of energy for the world. Oil production is characterized by high capital and high fixed costs - to produce a wide range of products through various stages of exploration and production, refining, marketing and transportation. In addition oil is a deplete resources whose price are determined by demand, supply and other variables. It should be noted that the supply of crude oil and demand for petroleum products is influenced by policies of producing and consuming governments too, especially in the medium and long-term.

In spite of the importance of the alternative oil resources, they are still cannot play a big role in the oil market because of the big difference in terms of cost, methods of

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REFERENCES

- Abdullah, M. H. (1998), the future of oil prices, *Journal of World Economy*, vol. 1: 28-29
- Abreu, D., & Brunnermeier, M. K. (2003). Bubbles and crashes. *Econometrica*, 71(1), 173-204.
- Acemoglu, D., Ticchi, D., & Vindigni, A. (2008). A theory of military dictatorships: National Bureau of Economic Research.
- Adelman, M. A. (1990). Mineral depletion, with special reference to petroleum. *The Review of Economics and Statistics*, 1-10.
- Adelman, M. A. (1995). *The genie out of the bottle: World oil since 1970*: The MIT press.
- Aguilera, R. F., Eggert, R. G., Gustavo Lagos, C. C., & Tilton, J. E. (2009). Depletion and the future availability of petroleum resources. *The Energy Journal*, 30 (1), 141-174.
- Akaike, H. (1977). On entropy maximization principle. *Application of statistics*.
- Alhajji, A. F., & Huettner, D. (2000). OPEC and world crude oil markets from 1973 to 1994: cartel, oligopoly or competitive? *Energy journal*-Cambridge, Ma then Cleveland, oh-, 21 (3), 31-60.
- Aliyu, S.U.R. 2009. Oil price shocks and the macroeconomy of Nigeria: a nonlinear approach. *Munich Personal RePEc Archive*.
- Al-Khuli, Fathi Ahmad, (1997), oil economy, fifth edition, king Abdul Aziz University, Jeddah: 232-233.
- Annual statistical bulletin. (2008, 2009).

- Alquwaiz, Abdullah Ibrahim, (1992), oil and the gulf cooperation council, opportunities in a changing world, cooperation Journal, vol. 26: 65-66
- Al-Sahlabi, M. A. (1986). Saudi and Gulf Cooperation Council oil supply: an econometric analysis.
- Azzam, H. T. (1976). The Middle Eastern oil exporting countries: absorptive capacity, market sharing, and investment strategies: University of Southern California. , 36-62.
- Aune, F. R., Mohn, K., Osmundsen, P., & Rosendahl, K. E. (2010). Financial market pressure, tacit collusion and oil price formation. *Energy Economics*, 32(2), 389-398.
- Bakhtiari, A. M. (1999). The price of crude oil. *OPEC review*, 23 (1), 1-21.
- Baltagi, B. H., & Griffin, J. M. (1983). Gasoline demand in the OECD: an application of pooling and testing procedures. *European Economic Review*, 22 (2), 117-137.
- Bekiros, S. D., & Diks, C. G. H. (2008). The relationship between crude oil spot and futures prices: Cointegration, linear and nonlinear causality. *Energy Economics*, 30 (5), 2673-2685.
- Banks, M. K. Wiltse, C. C., Rooney, W. L., Chen, Z., & Schwab, A. P., (1998). Greenhouse evaluation of agronomic and crude oil-phytoremediation potential among alfalfa genotypes. *Journal of Environmental Quality*, 27 (1), 169-173.
- Bernanke, Ben S., Boivin, Jean, Elias, Pitr, 2008. Measuring the effects of monetary policy: a Factor-Augmented Vector Autoregressive (FAVAR) approach. *Quarterly Journal of Economics* 120 (1), 387-422
- Blum, U. C., Foos, G., & Gaudry, M. J. (1988). Aggregate time series gasoline

- demand models: Review of the literature and new evidence for West Germany. *Transportation Research Part A: General*, 22(2), 75-88.
- Blume, L. E. (2008). The New Palgrave Dictionary of Economics. New Books List April-June 2008.
- Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of econometrics*, 31(3), 307-327.
- Borenstein, S. (2008). *Cost, Conflict and Climate: US Challenges in the World Oil Market*.
- Borenstein, S., Cameron, A. C., & Gilbert, R. (1997). Do gasoline prices respond asymmetrically to crude oil price changes? *The Quarterly Journal of Economics*, 112 (1), 305-339.
- Brennan, M. J. (1958). The supply of storage. *The American Economic Review*, 48 (1), 50-72.
- Britannica, E. (2008). *Ultimate Reference Suite*. Chicago: Encyclopædia Britannica.
- Brunnermeier, M. K. (2001). *Asset pricing under asymmetric information: Bubbles, crashes, technical analysis, and herding*: OUP Oxford.
- Brunnermeier, M. K. (2008). *Deciphering the liquidity and credit crunch 2007-08* (No. w14612). National Bureau of Economic Research.
- Gileva, T. (2010). *Econometrics of Crude Oil Markets*.
- Chen, S. S., & Chen, H. C. (2007). Oil prices and real exchange rates. *Energy Economics*, 29 (3), 390-404.
- Chevalier, J. (2009). *Winning the Battle*. Chevalier, J. ed, 256-280.
- Chevalier, J. M., Baule, F., Lasserre, F., Odonnat, I., Viellefond, E., & Laffitte, M. (2010). *Report of the working group on oil price volatility*. French Ministry

for the Economy, Industry and Employment.

Cr mer, J., & Salehi-Isfahani, D. (1991). *Models of the oil market* (Vol. 2). Taylor & Francis.

D  es, S., Gasteuil, A., Kaufmann, R. K., Mann, M., & European Central, B. (2008). *Assessing the factors behind oil price changes*: European Central Bank.

Dahl, C. A. (2004). *International energy markets: understanding pricing, policies, and profits*: Pennwell Books.

Dake, L. P. (2001). *The practice of reservoir engineering* (Vol. 36): Elsevier Science.

Daniel, Y. (1991). *The prize: The epic quest for oil, money and power*: New York: Simon & Schuster.

Dees, S., Karadeloglou, P., Kaufmann, R.K., Sanchez, M.(2007). *Modelling the world oil market: assessment of a quarterly econometric model*. *Energy Policy*: 35, 178–191.

Dickey, D. A., & Fuller, W. A. (1979). *Distribution of the estimators for autoregressive time series with a unit root*. *Journal of the American statistical association*, 427-431.

Energy Information Administration, 2007-2010

Eltony, M. N., & Al-Mutairi, N. H. (1995). *Demand for gasoline in Kuwait: an empirical analysis using cointegration techniques*. *Energy Economics*, 17(3), 249-253.

Enders, W. (2004). *Applied Econometric Time Series* , by Walter. *Technometrics*, 46(2).

Ezzati, A. (1976). *Future OPEC price and production strategies as affected by its*

- capacity to absorb oil revenues. *European Economic Review*, 8(2), 107-138.
- Ezzati, A. (1978). World energy markets and OPEC stability.
- Fattouh, B. The dynamics of crude oil price differentials. *Energy Economics*, 32(2), 334-342.
- Fattouh, B. (2006). The origins and evolution of the current international oil pricing system: A critical assessment. *Oil in the 21st century: issues, challenges and opportunities*, 41-100.
- Fattouh, B. (2007). The drivers of oil prices: The usefulness and limitations of non-structural models, supply-demand frameworks, and informal approaches. *EIB Papers*, 12(1), 128-156.
- Fattouh, B., & Oxford Institute for Energy, S. *An Anatomy of the Crude Oil Pricing System: Oxford Institute for Energy Studies*.
- Fattouh, B., & Oxford Institute for Energy, S. (2009). *Basis variation and the role of inventories: evidence from the crude oil market: Oxford Institute for Energy Studies*.
- Fattouh, B., 2010. The dynamics of crude oil price differentials. *Energy Economics* 32 (2), 334–342.
- Federal Trade, C. (2006). *Gasoline Price Changes: The Dynamic of Supply, Demand, and Competition* (2005).
- Federal Reserve Bank of San Francisco, 2005.
- Frankel, J. A. (2006). The effect of monetary policy on real commodity prices: *National Bureau of Economic Research*.
- Fuhrer, J. C. (1995). The Phillips curve is alive and well. *New England Economic Review*, 41-41.

- Gaudet, G. (2007). Natural resource economics under the rule of Hotelling. *Canadian Journal of Economics/Revue canadienne d'Économie*, 40(4), 1033-1059.
- Gately, D., & Huntington, H. G. (2001). The asymmetric effects of changes in price and income on energy and oil demand. CV Starr Center for Applied Economics.
- Gileva, T. (2010). *Econometrics of Crude Oil Markets* (Doctoral dissertation, Thesis submitted to the Department of Economics, University of Paris).
- Gray, L. C. (1914). Rent under the Assumption of Exhaustibility. *The Quarterly Journal of Economics*, 466-489.
- Griffin, J. M., & Teece, D. J. (1982). OPEC Behavior and World Oil Prices.
- Griffin, J. M., & Teece, D. J. (1986). OPEC behavior and world oil prices, 5.
- Griffin, J. M., & Xiong, W. (1997). The Incentive to Cheat: An Empirical Analysis of OPEC 1. *The Journal of Law and Economics*, 40 (2), 289-316.
- Gurrib, I. (2007). The Impact of Speculators' Activity on Crude Oil Futures Prices.
- Hamilton, J. D. (1996). This is what happened to the oil price-macroeconomy relationship. *Journal of Monetary Economics*, 38 (2), 215-220.
- Hamilton, J. D. (2008). Understanding crude oil prices: National Bureau of Economic Research.
- Hamilton, J. D. (2009). Causes and Consequences of the Oil Shock of 2007-2008: *Brookings Papers on Economic Activity*, pp. 215–261.
- Hamilton, J. D. (2011). Historical oil shocks (No. w16790). National Bureau of Economic Research.
- Hart, R., & Spiro, D. (2011). The elephant in Hotelling's room. *Energy Policy*, 39 (12), 7834-7838.

- Hassan, S. A. Modeling Asymmetric Volatility In Oil Prices. *Journal of Applied Business Research (JABR)*, 27(3), 71-78.
- Herwartz, H., & Lütkepohl, H. (2011). Structural vector autoregressions with Markov switching: Combining conventional with statistical identification of shocks.
- Holden, K. (1997). A comparison of forecasts from UK economic models and some Bayesian vector autoregressive models. *Journal of Economic Studies*, 24 (4), 242-256.
- Holditch, S. A., & Chianelli, R. R. (2008). Factors that will influence oil and gas supply and demand in the 21st century. *MRS bulletin*, 33.
- Hooker, M. A. (2002). Are oil shocks inflationary? Asymmetric and nonlinear specifications versus changes in regime. *Journal of Money, Credit and Banking*, 540-561.
- Horsnell, P., & Mabro, R. (1993). Oil markets and prices: The Brent market and the formation of world oil prices.
- Hotelling, H. (1931). The economics of exhaustible resources. *The Journal of Political Economy*, 39 (2), 137-175.
- Hul, J. (2003). *Options, Futures, and Other Derivatives*: Prentice Hall, New Jersey.
- Insel, A., & Tekçe, M. (2010). Econometric analysis of the bilateral trade flows in the Gulf Cooperation Council countries.
- International Energy Agency, (2007-2010).
- International monetary fund. (1997, 2008). *World economic outlook – financial stress, downturns, and recoveries*, Washington, DC.
- Jackson, J. K. *US Trade Deficit, the Dollar, and the Price of Oil*: DIANE Publishing.

- Janne Happonen, (2009), a review of factors determining oil prices, Helsinki school of economics, A thesis submitted in partial fulfillment of the requirements master degree at the Helsinki school of economics: 51-57
- Jean Marie Chevalier, (2010) "oil price volatility", report of the working group chaired by professor Jean Marie Chevalier foreword, executive summary and proposals: 1-5
- Jenkins, G. (1990). *Oil Economists' Handbook: Statistics* (Vol. 1): Routledge.
- Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of economic dynamics and control*, 12 (2-3), 231-254.
- Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration with applications to the demand for money. *Oxford Bulletin of Economics and statistics*, 52 (2), 169-210.
- Jolliffe, I. T. (2002). *Principal component analysis*. Springer-Verlag, New York, second edition.
- Jones, C. T. (1990). OPEC behavior under falling prices: implications for cartel stability. *The Energy Journal*, 11 (3), 117-130.
- Kang, S. H., Kang, S. M., & Yoon, S. M. (2009). Forecasting volatility of crude oil markets. *Energy Economics*, 31 (1), 119-125.
- Kaufmann, R. K. The role of market fundamentals and speculation in recent price changes for crude oil. *Energy Policy*, 39 (1), 105-115.
- Kaufmann, R. K. (1995). A model of the world oil market for project LINK Integrating economics, geology and politics. *Economic Modelling*, 12(2), 165-178.
- Kaufmann, R. K., & Cleveland, C. J. (2001). Oil production in the lower 48 states:

- economic, geological, and institutional determinants. *Energy Journal*-Cambridge Ma then Cleveland Oh-, 22 (1), 27-50.
- Kaufmann, R. K., Dees, S., Karadeloglou, P., & Sanchez, M. (2004). Does OPEC matter? An econometric analysis of oil prices. *The Energy Journal*, 25(4), 67-90.
- Kaufmann, R. K., Dees, S., Gasteuil, A., & Mann, M. (2008). Oil prices: the role of refinery utilization, futures markets and non-linearities. *Energy Economics*, 30 (5), 2609-2622.
- Kaufmann, R. K., & Ullman, B. (2009). Oil prices, speculation, and fundamentals: Interpreting causal relations among spot and futures prices. *Energy Economics*, 31 (4), 550-558.
- Kaufmann, R. K. (2011). The role of market fundamentals and speculation in recent price changes for crude oil. *Energy Policy*, 39 (1), 105-115.
- Kesicki, F., Remme, U., Blesl, M., Fahl, U., & Voř, A. (2009). The third oil price surge—What is different this time and what are possible future oil price developments?
- Kilian, L. (2009). Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market. *The American Economic Review*, 99 (3), 1053-1069.
- Kilian, L., (2009a). Comment on causes and consequences of the oil shock of 2007–2008. *Brookings Papers on Economic Activity Spring 2009*, 267–284.
- Kilian, L., (2009b). Not all oil price shocks are alike: disentangling demand and supply shocks in the crude oil market. *American Economic Review* 99 (3), 1053–1069.

- Kilian, L. (2009c). Oil price shocks, monetary policy and stagflation. *Ann Arbor*, 1001, 48109-41220.
- Kisswani, K. M. Economics of oil prices and the role of OPEC. University of Connecticut.
- Kisswani, K. (2014). OPEC and political considerations when deciding on oil extraction. *Journal of Economics and Finance*, 38 (1), 96-118.
- Krautkraemer, J. A. (1998). Nonrenewable resource scarcity. *Journal of Economic Literature*, 2065-2107.
- Krautkraemer, J. A. (2005). Economics of natural resource scarcity: the state of the debate.
- Krichene, N. (2002). World crude oil and natural gas: a demand and supply model. *Energy Economics*, 24 (6), 557-576.
- Krichene, N. (2005). A simultaneous equation model for world crude oil and natural gas markets (No. 5-32). International Monetary Fund.
- Krichene, N. (2006). A simultaneous equations model for world crude oil and natural gas markets.
- Krichene, N. (2007). An oil and gas model: International Monetary Fund.
- Krichene, N & Askari, H.,. (2008). Oil price dynamics (2002–2006). *Energy Economics*, 30 (5), 2134-2153.
- Le Billon, P., & El Khatib, F. (2004). From free oil to ‘freedom oil’: Terrorism, war and US geopolitics in the Persian Gulf. *Geopolitics*, 9 (1), 109-137.
- Le Billon, P., & Cervantes, A. (2009). Oil prices, scarcity, and geographies of war. *Annals of the Association of American Geographers*, 99 (5), 836-844.
- Lee, C. C., & Lee, J. D. A panel data analysis of the demand for total energy and

- electricity in OECD countries. *The Energy Journal*, 31(1), 1-24.
- Li, M. (2007). Peak oil, the rise of China and India, and the global energy crisis. *Journal of Contemporary Asia*, 37(4), 449-471.
- Lin, C. Y. Cynthia. (2008). Insights from a Simple Hotelling Model. *Natural Resources Research*, 18(1).
- Liu, P., & Tang, K. (2011). The stochastic behavior of commodity prices with heteroskedasticity in the convenience yield. *Journal of Empirical Finance*, 18(2), 211-224.
- Litzenberger, R. H., & Rabinowitz, N. (1995). Backwardation in oil futures markets: Theory and empirical evidence. *The Journal of Finance*, 50 (5), 1517-1545.
- Ljung, G. M., & Box, G. E. P. (1978). On a measure of lack of fit in time series models. *Biometrika*, 65 (2), 297-303.
- Lorentsen, L., & Roland, K. (1986). The World Oil Market (WOM) Model: An Assessment of the Crude Oil Market Through 2000. *The Energy Journal*, 7 (1), 23-34.
- MacAvoy, P. W. (1982). Crude oil prices as determined by OPEC and market fundamentals.
- Mo伯特, J. (2007). Crude oil price determinants. Publications of Darmstadt Technical University, Institute of Economics (VWL).
- Mabro, R., Bacon, R., Chadwick, M., Halliwell, M., & Long, D. (1986). The market for North Sea crude oil.
- Mabro, R., & Oxford Institute for Energy, S. (1987). Netback pricing and the oil price collapse of 1986: Oxford Institute for Energy Studies.
- Mabro, R. (1992). OPEC and the Price of Oil. *The energy journal*, 1-17.

- MacAvoy, P. W. (1982). Crude oil prices as determined by OPEC and market fundamentals.
- Maslyuk, S., & Smyth, R. (2008). Unit root properties of crude oil spot and futures prices. *Energy Policy*, 36(7), 2591-2600.
- Masters, M. W. (2008). Testimony before the Committee on Homeland Security and Governmental Affairs. US Senate, Washington, May, 20.
- Mazraati, M., & Jazayeri, S. M. (2004). Oil price movements and production agreements. *OPEC review*, 28(3), 207-226.
- McRae, R. (1994). Gasoline demand in developing Asian countries. *The Energy Journal*, 143-155.
- Milonas, N. T., & Henker, T. (2001). Price spread and convenience yield behaviour in the international oil market. *Applied Financial Economics*, 11 (1), 23-36.
- Mirak-Weissbach, M. (2007). "Dollar crash: The real challenge for OPEC". *Global research*, November.
- Moazzami, B., & Anderson, F. J. (1994). Modelling natural resource scarcity using the error-correction'approach. *Canadian Journal of Economics*, 801-812.
- Mobert, J. (2007). Crude oil price determinants (No. 186). Darmstadt discussion papers in economics.
- Morris Adelman. (1978). "Constraints on the world monopoly prices", resources and energy. Vol. 1, 3-19.
- Morrison, M. B. (1987). Will oil demand recover? A challenge to a consensus. *Petroleum Review*, 47.
- Nandha, M., & Faff, R. (2008). Does oil move equity prices? A global view. *Energy Economics*, 30 (3), 986-997.

- Narayan, P. K., & Narayan, S. (2007). Modelling oil price volatility. *Energy Policy*, 35(12), 6549-6553.
- Noreng, J. M. K., Birkett, J. W. & Lester, J. N. (2002). Spatial distribution of mercury in the sediments and riparian environment of the River Yare, Norfolk, UK. *Environmental Pollution*, 116(1), 65-74.
- Northwest energy policy workshop. (1980). petroleum in the Northwest; disruption or transition, 38-66.
- Outlook, A. E. Energy Information Administration. US Department of Energy, Januar.
- Palo Alto (1982). Energy modeling forum VI, world oil., CA: Stanford University, 3-11.
- Papapetrou, E. (2001). Oil price shocks, stock market, economic activity and employment in Greece. *Energy Economics*, 23 (5), 511-532.
- Papapetrou, E. (2001). Oil price shocks, stock market, economic activity and employment in Greece. *Energy Economics*, 23 (5), 511-532.
- Peter Ferderer, J. (1996). Oil price volatility and the macroeconomy. *Journal of Macroeconomics*, 18 (1), 1-26.
- Pindyck, R. S. (1978). The optimal exploration and production of nonrenewable resources. *The Journal of Political Economy*, 841-861.
- Pindyck, R. S., & Rubinfeld, D. L. (1981). *Econometric models and economic forecasts* (Vol. 2): McGraw-Hill New York.
- Polasky, S. (1992). The private and social value of information: exploration for exhaustible resources. *Journal of Environmental Economics and Management*, 23 (1), 1-21.
- Radetzki, M. (2006). The anatomy of three commodity booms. *Resources Policy*,

31(1), 56-64.

Regnier, E. (2007). Oil and energy price volatility. *Energy Economics*, 29(3), 405-427.

Reuters, T. (2009). The Thomson Reuters journal selection process. Thomson Reuters.

Ringlund, G. B., Rosendahl, K. E., & Skjerpen, T. (2008). Does oilrig activity react to oil price changes? An empirical investigation. *Energy Economics*, 30 (2), 371-396.

Robert J. Weiner, (2008), Oil price volatility, what do we know? , George Washington University, Washington: 19-20

Sadorsky, P. (1999). The relationship between environmental commitment and managerial perceptions of stakeholder importance. *Academy of management Journal*, 42 (1), 87-99.

Sadorsky, P. (2003). The macroeconomic determinants of technology stock price volatility. *Review of Financial Economics*, 12 (2), 191-205.

Sampson, A. (1975). *The seven sisters: the great oil companies and the world they shaped*: Bantam Books New York, NY.

Seng, Y. A. (2007). Oil price movement, stock market performance and real activity: a multi country experience master of business administration. Penang, USM. Master: 1-31

Shepherd, B. P. (2009). Analyzing the factors behind crude oil price increases from 2002--2007 and the implications for the oil industry: A non-technical assessment. University of Denver.

Shleifer, A., & Summers, L. H. (1990). The noise trader approach to finance. *The*

- Journal of Economic Perspectives, 4(2), 19-33.
- Simmons, M. R. (2005). *Twilight in the desert: The coming Saudi oil shock and the world economy*: Wiley.
- Slade, M. E. (1982). Trends in natural-resource commodity prices: an analysis of the time domain. *Journal of Environmental Economics and Management*, 9(2), 122-137.
- Smith, L. I. (2002). A tutorial on Principal Components Analysis Introduction.
- Snyder, C. R., & Lopez, S. J. (2009). *Oxford handbook of positive psychology*: Oxford University Press, USA.
- Solow, R. M. (2008). The economics of resources or the resources of economics. *Journal of Natural Resources Policy Research*, 1 (1), 69-82.
- Sterner, T., & Dahl, C. A. (1992). Modelling transport fuel demand. In *International energy economics* (pp. 65-79). Springer Netherlands.
- Stevens, P. (1995). The determination of oil prices 1945–1995: a diagrammatic interpretation. *Energy Policy*, 23 (10), 861-870.
- Stevens, P. (2009). *The coming oil supply crunch*: Chatham House.
- Stiglitz, J. E. (1976). Monopoly and the rate of extraction of exhaustible resources. *The American Economic Review*, 655-661.
- Stock, J. H., & Watson, M. W. (1993). A simple estimator of cointegrating vectors in higher order integrated systems. *Econometrica: Journal of the Econometric Society*, 783-820.
- Snyder, C. R., & Lopez, S. J. (2009). *Oxford handbook of positive psychology*: Oxford University Press, USA.
- Stock, James H., Watson, Mark W., 2002. *Macroeconomic forecasting using*

- diffusion indexes. *Journal of Business and Economic Statistics* 20, 147–162.
- Treasury, H. M. (2008). *Global Commodities: a long term vision for stable, secure and sustainable global markets*. HM Treasury, London June.
- Tunsjø, Ø. (2010). Hedging against oil dependency: New perspectives on China's energy security policy. *International Relations*, 24(1), 25-45.
- Vactor, S. A., & Tussing, A. R. (1987). Retrospective on Oil Prices. *Contemporary Economic Policy*, 5 (3), 1-19.
- Verleger, P. K. (1991). *Structural change in the 1980s. After the Oil Price Collapse*, Johns Hopkins University Press, Baltimore, MD.
- Verleger, P. K. (1994). *Adjusting to volatile energy prices (Vol. 39)*: Peterson Institute.
- Verleger, P. K., & Philip, K. (2008). The Oil-Dollar Link. *International Economy*, 22 (2), 46.
- Vo, M. T. (2009). Regime-switching stochastic volatility: Evidence from the crude oil market. *Energy Economics*, 31 (5), 779-788.
- Wasserfallen, W., & Güntensperger, H. (1988). Gasoline consumption and the stock of motor vehicles: An empirical analysis for the Swiss economy. *Energy economics*, 10 (4), 276-282.
- Watkins, G. C., & Streifel, S. S. (1998). World crude oil supply: evidence from estimating supply functions by country. *Journal of Energy Finance & Development*, 3 (1), 23-48.
- Wirl, F. (2008). Why do oil prices jump (or fall)? *Energy Policy*, 36 (3), 1029-1043.
- Working, H. (1949). The theory of price of storage. *The American Economic Review*, 39 (6), 1254-1262.

- X. Bai, J. R. Russell, and G. C. Tiao. Kurtosis of GARCH and stochastic volatility models with non-normal innovations. (2002). *Journal of Econometrics*, 114(2):349–360, 2003. <http://www.sciencedirect.com/science/article/B6VC0-484VG9K>
- Xu, W., Wang, J., & Ma, J. Forecasting Crude Oil Demand Using a Hybrid SVR and Markov Approach. *Business Intelligence in Economic Forecasting: Technologies and Techniques*, 235.
- Yousefi, A., & Wirjanto, T. S. (2004). The empirical role of the exchange rate on the crude-oil price formation. *Energy Economics*, 26 (5), 783-799.
- Zagaglia, P. (2010). Macroeconomic factors and oil futures prices: A data-rich model. *Energy Economics*, 32 (2), 409–417. Do: 10.1016/j. Eneco. 2009.11.003